Dairy Manure Management:
Treatment, Handling, and Community Relations

AD Performance Goals:
Affect on System Components and Costs

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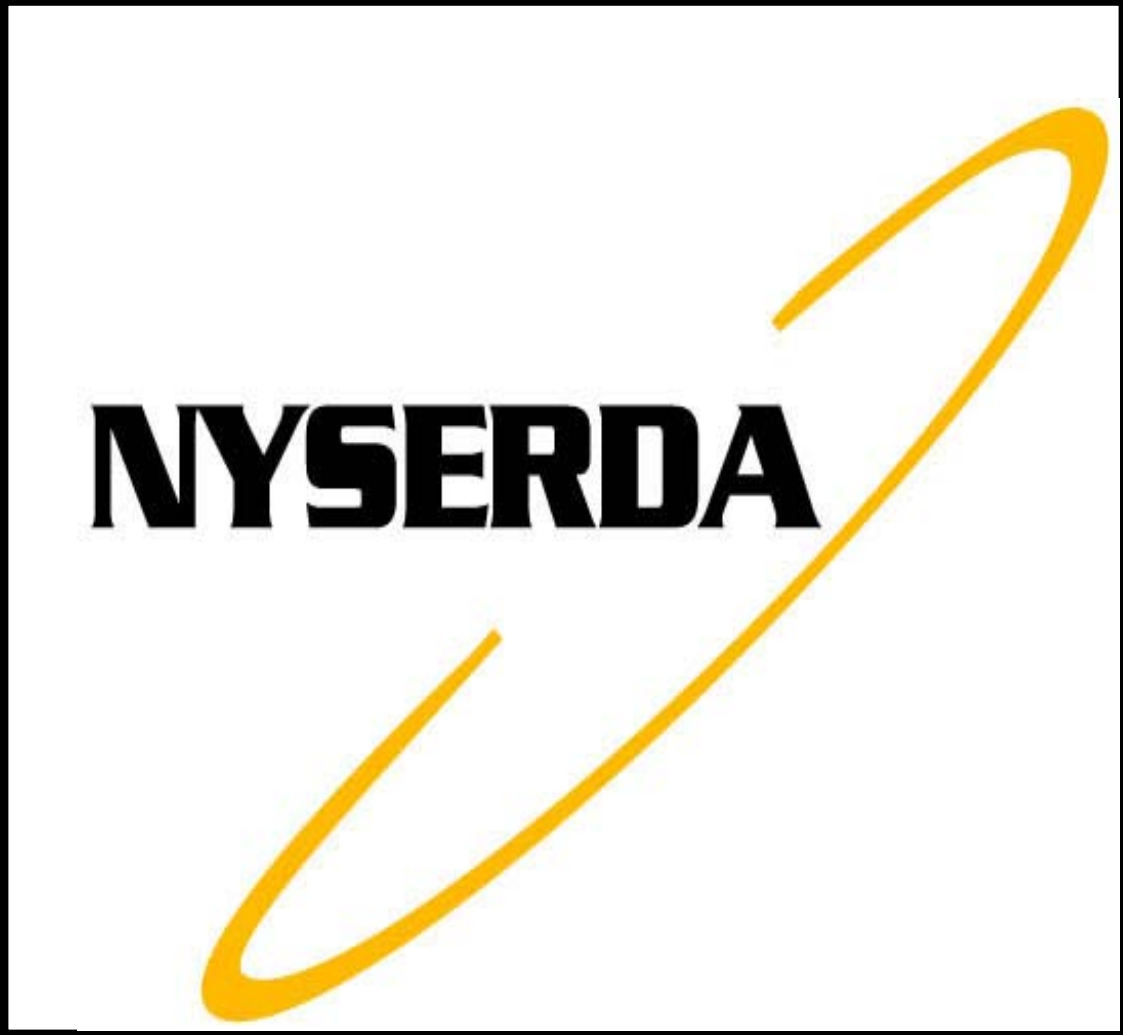
PRO-DAIRY

www.prodairyfacilities.cornell.edu


NYSERDA

Waste Treatment System

- Support the overall goals, objectives, and needs for the farm
- These vary from farm to farm

Potential Goals and Objectives

- Removal of manure solids
  - ☞ easier pumping to remote storage
  - ☞ easier field application

Potential Goals and Objectives

- Removal of bedding sand to:
  - ☞protect subsequent treatment equipment
  - ☞reuse as stall bedding material
  - ☞reduce field compaction

Potential Goals and Objectives

- Odor Reduction

Potential Goals and Objectives

- Electrical generation to:
  - ☞Meet on-farm needs
  - ☞Sell to the utility

Potential Goals and Objectives

- Conservation of manure nutrients
- Reduce pathogens

Integrated Manure Management System

Goals and Objectives of Paper

Present the relationships that exists between manure **management goals**, **treatment equipment**, and **economics** for a treatment system centered around *Anaerobic Digestion*

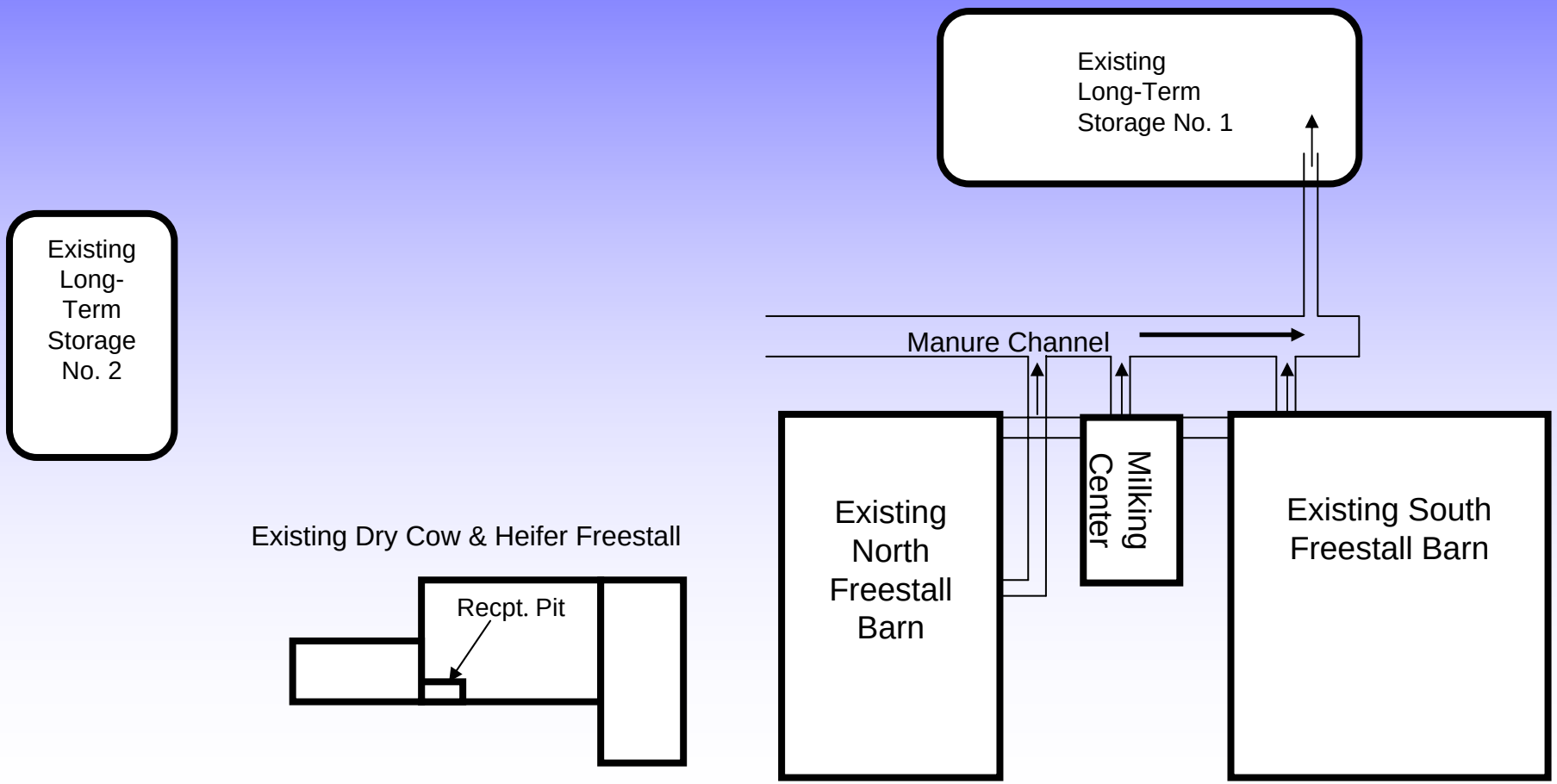
Implementation

- Analyze four manure treatment systems
- Each successive system will build on the previous
- Synthesize the results and form conclusions

Background

- Data obtained from a feasibility study conducted for a NYS producer in 2004
- 800 lactating cows, 100 dry cows, and 400 heifers weighing on ave. 1,000 lbs
- Manure production estimated to be 144, 78, and 53 lbs. per day, respectively

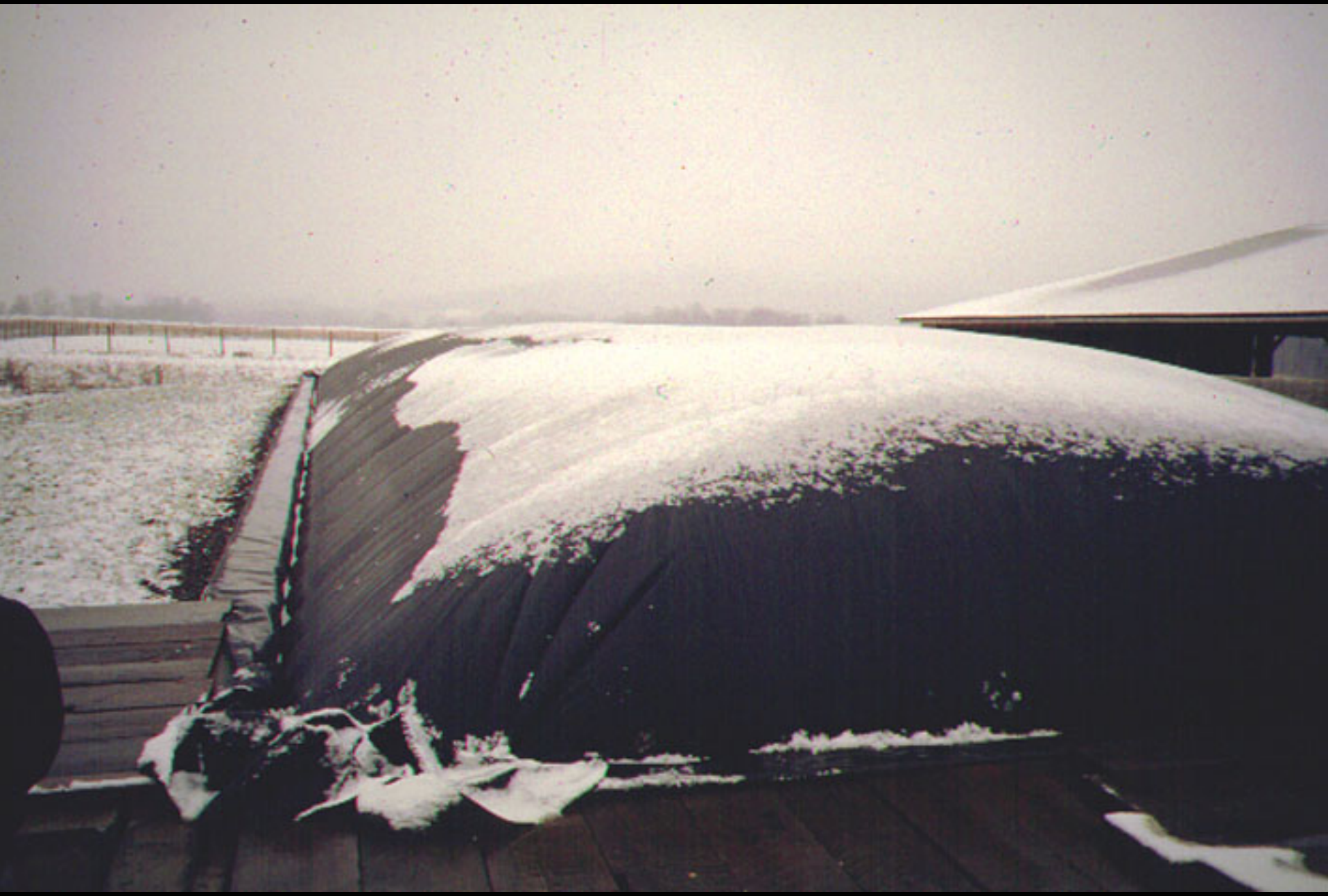
Existing Site Plan



Four Options Analyzed

- Option I. Liquid manure odor reduction
- Option II. Option I + electrical generation
- Option III. Option II + bedding material generation & nutrient exportation
- Option IV. Option III + w/ rotary composting

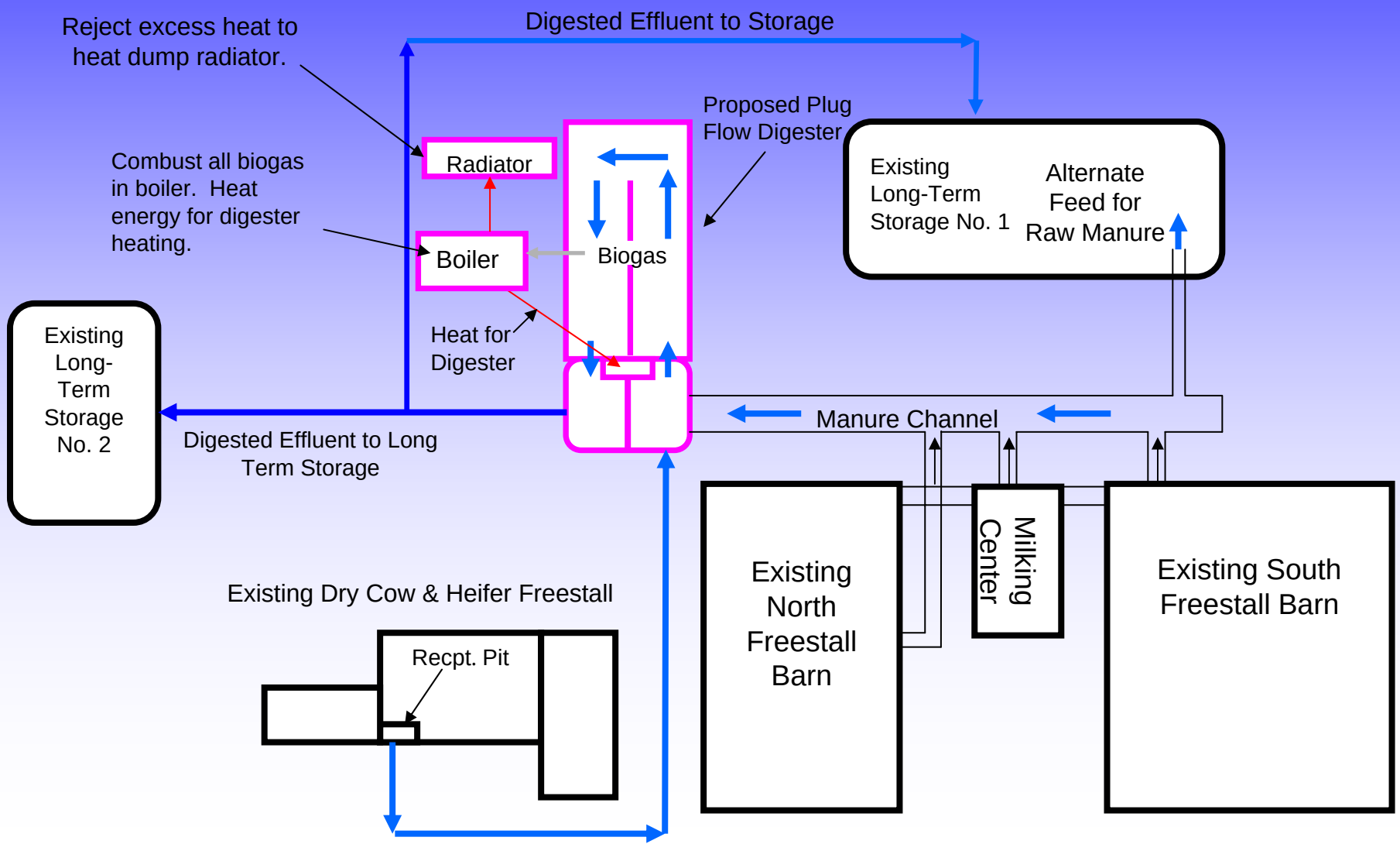
Option	I	II	III	IV
Digester Type	Plug Flow	Plug Flow	Plug Flow	Plug Flow
Temperature (F)	100	100	100	100
HRT (days)	11	21	21	21
Est. Gas Production (cu. ft./cow – day)	30	70	70	70
Heat Balance	Positive	Positive	Positive	Positive



First Option Analyzed

Option I. Liquid manure odor reduction

Site Plan for Option I



Option I – Est. Capital Costs

	Facility	Equipment
Digester/Recpt. Pit	122,947	
Bldg, reception	8,000	
Manure cross channel	10,000	
Boilers		8,000
Steam gen. & heat exchanger		10,000
Chopper pump		10,000
Plumbing - manure & AD heating		11,000
Valves & meter		2,000
Excavation	8,619	
Misc. material & labor	2,000	3,000
Sub totals	151,566	44,000
Design/Supervision	3,911	3,911
Contingency	3,911	3,911
Misc. Material & Labor	1,956	1,956
Sub totals	9,778	9,778
Facility & Equipment Total:	**$215,123**	

Sample Economic Analysis for Waste Treatment

Enter No. Cows Serviced Here:	500	
Enter Ave. Electrical Cost Here:	0.1	$/kW-hr.

Total Annual Est. Cost for Ave. No. of Cows Serviced Daily $37,585.22

Initial Investments, Fixed, and Operating Cost Calculation by Co

Component No.1	20' X 22' Sand Manure Separater
a. Initial Capital Investment	$29,600.00
b. Installation Cost	$400.00
c. Useful Life, Years	20
d. Salvage Value	$2,960.00
e. Interest on Investment	0.05
f. Average Investment (a+b+d)/2	$16,480.00
g. Annual Interest Charge (e x f)	$824.00
h. Annual Depreciation, linear	$1,352.00
I. Annual Preventative Maitenance	$45.00
j. Annual Repairs Over Useful Life	$123.57
k. Annual Electrical Cost	$1,520.83
l. Annual Labor Hours	2.41
m. Labor Rate, all costs	16
n. Annual Labor Costs (l x m)	$38.51
Total Annual Cost for Component: (g+h+I+j+k+n)**:**	$3,903.92

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n. Annual Labor Costs (l x m)	$38.51
Total Annual Cost for Component: (g+h+I+j+k+n):	$3,903.92

Comparison Summary Costs ($) for the Four Options Analyzed

	Option I	*Option II*	*Option III*	*Option IV*
Total Capital Cost	215,100			
Total Capital Cost Per Cow	269			
Total Est. Annual Capital Cost	18,400			
Total Est. Annual Capital Cost Per Cow	23			
Total Est. Annual Operating Cost	12,000			
Total Est. Annual Operating Cost Per Cow	15			
Total Est. Annual Cost	30,400			
Total Est. Annual Cost Per Cow	38			
Total Est. Annual Revenues	----			
Total Est. Annual Revenues Per Cow	----			
Total Est. Annual Cost or Benefit[1, 2]	-30,400			
Total Est. Annual Cost or Benefit Per Cow	-38			

Represents the annual cost to control liquid manure odor for the farm

[1]Does not include treatment system electrical use (parasitic power)

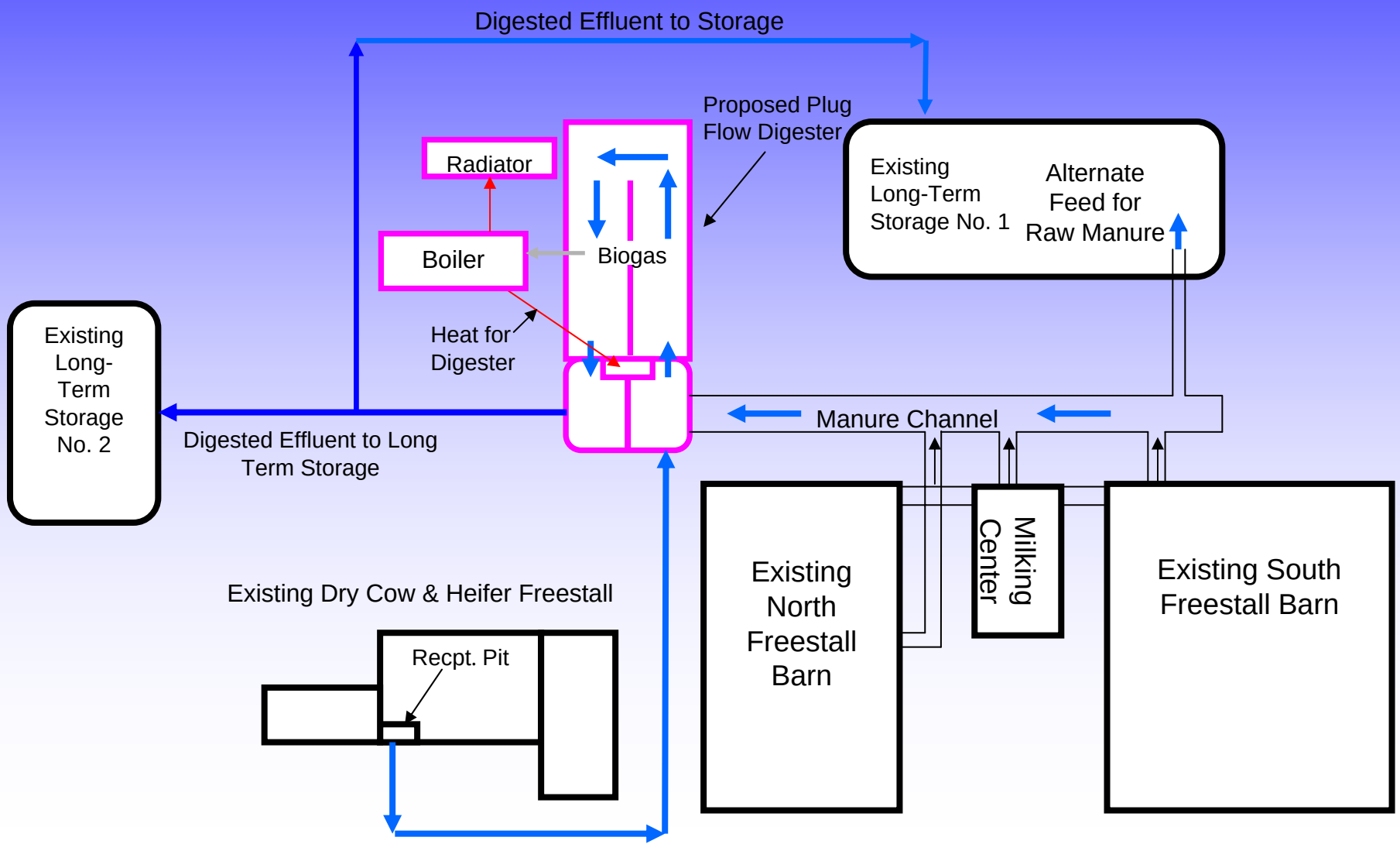
[2]Negative numbers mean that the farm incurs a net loss from the digester system.

Second Option Analyzed

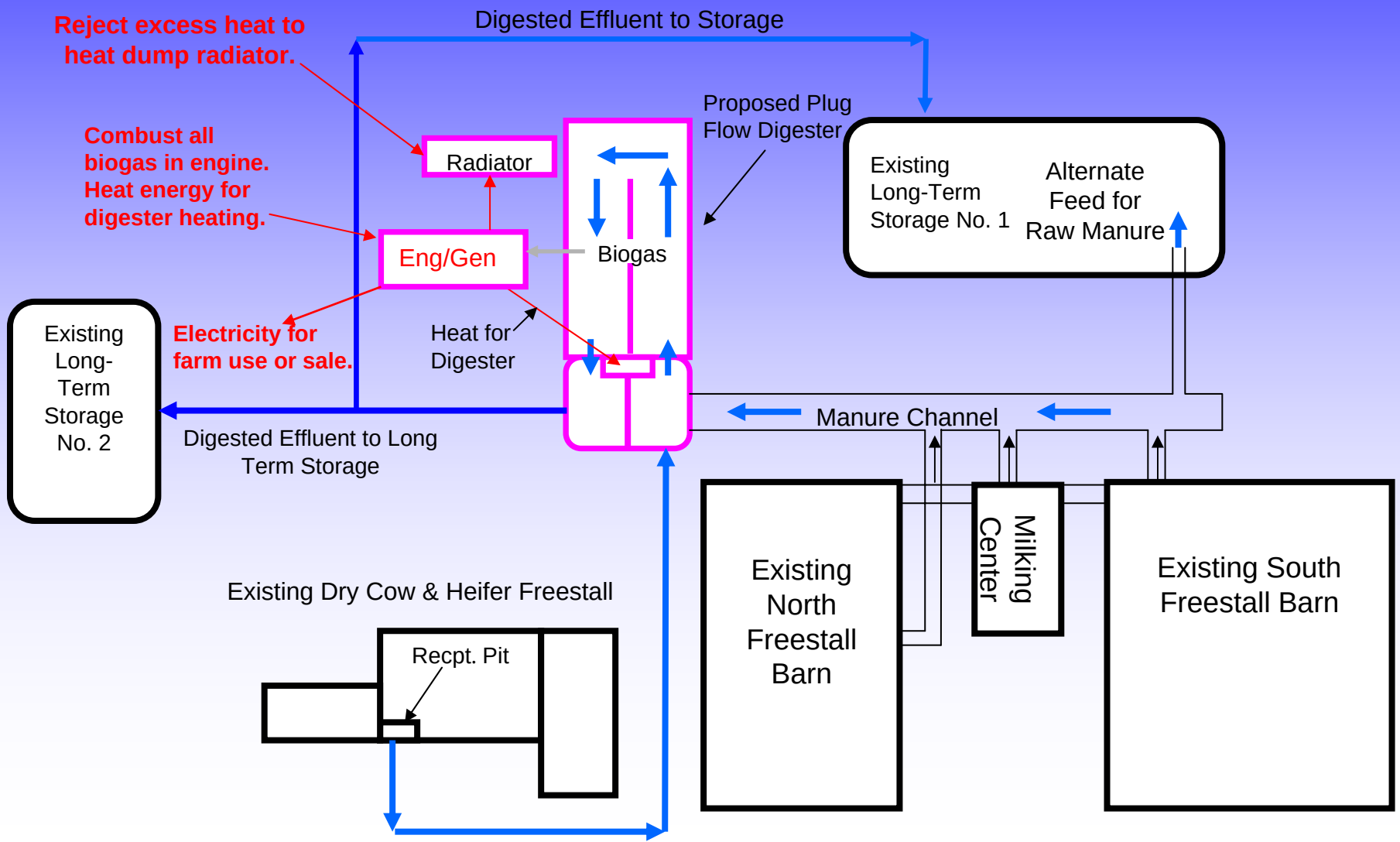
Option I. Liquid manure odor reduction

Option II. Option I + electrical generation

Site Plan for Option II



Site Plan for Option II



Comparison Summary Costs ($) for the Four Options Analyzed

	Option I	*Option II*	*Option III*	*Option IV*
Total Capital Cost	215,100	482,000		
Total Capital Cost Per Cow	269	603		
Total Est. Annual Capital Cost	18,400	45,100		
Total Est. Annual Capital Cost Per Cow	23	56		
Total Est. Annual Operating Cost	12,000	23,700		
Total Est. Annual Operating Cost Per Cow	15	30		
Total Est. Annual Cost	30,400	68,800		
Total Est. Annual Cost Per Cow	38	86		
Total Est. Annual Revenues	----	66,000		
Total Est. Annual Revenues Per Cow	----	82		
Total Est. Annual Cost or Benefit[1, 2]	-30,400	-2,800		
Total Est. Annual Cost or Benefit Per Cow	-38	-3.50		

- Increased HRT
- 125 KW engine/gen set
- Gas processing bldg.
- Plumbing and electrical

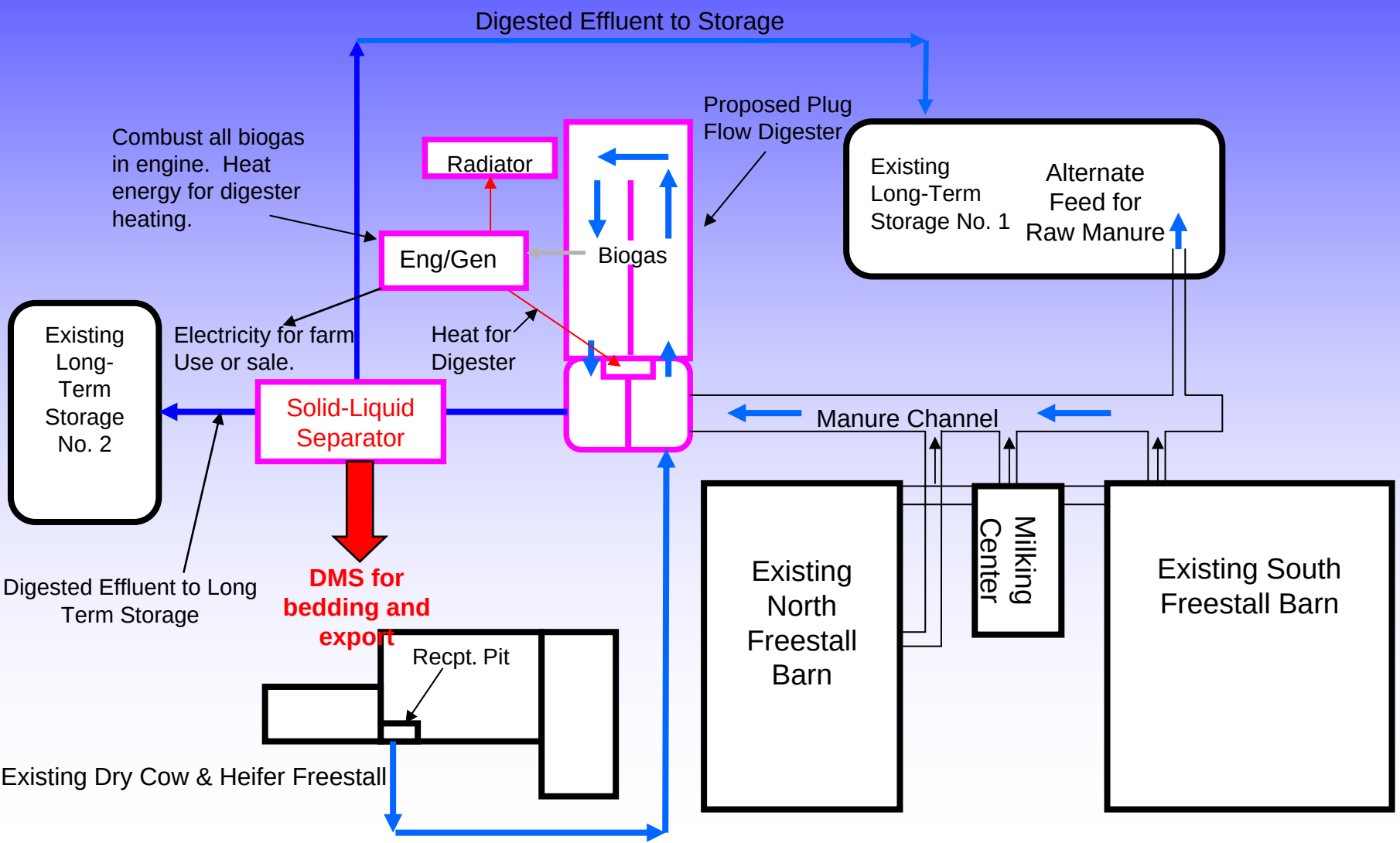
[1]Does not include treatment system electrical use (parasitic power)

[2]Negative numbers mean that the farm incurs a net loss from the digester system.

Third Option Analyzed

Option I.	Liquid manure odor reduction
Option II.	Option I + electrical generation
Option III.	Option II + bedding material generation & nutrient exportation

Site Plan for Option III

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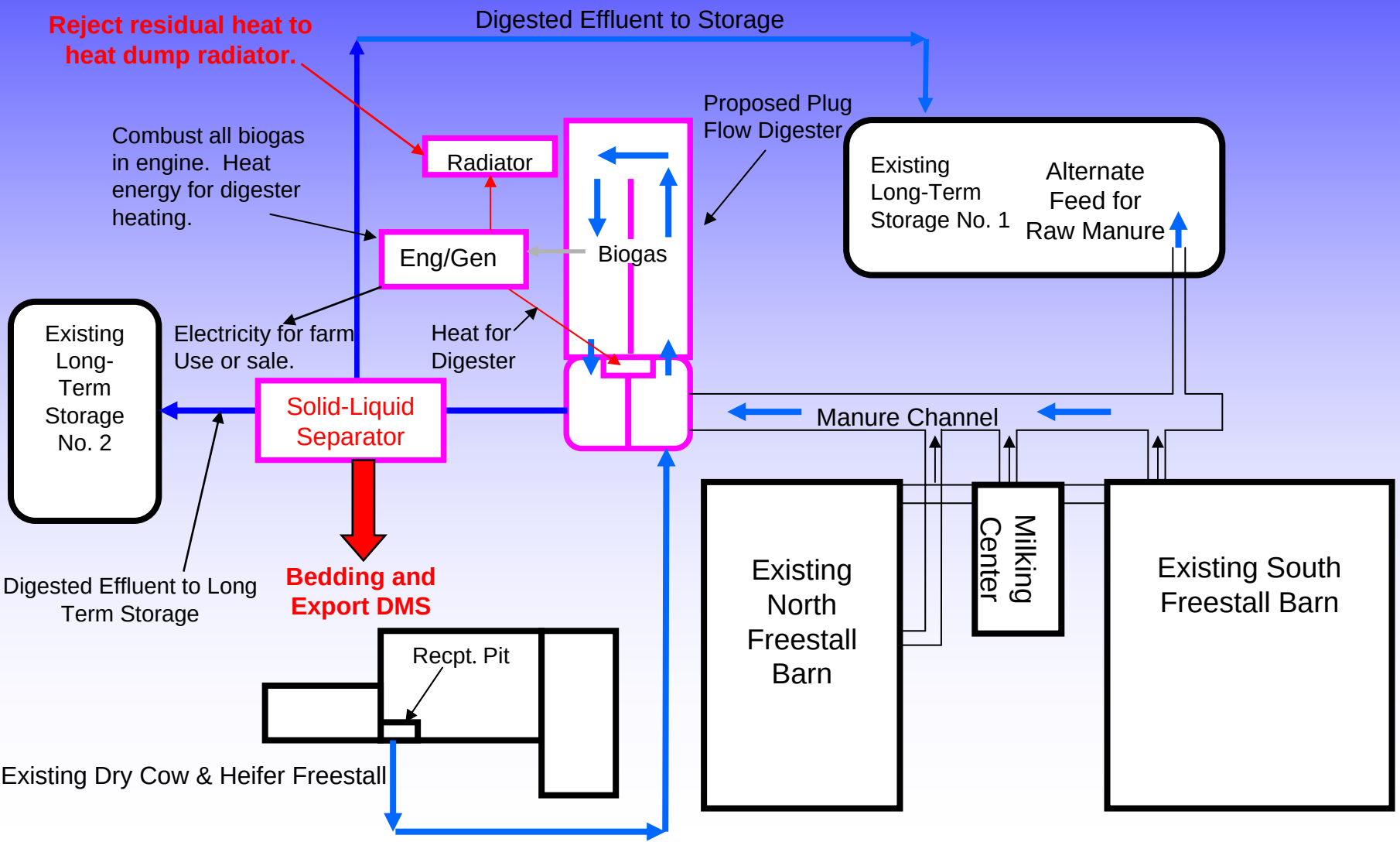
Site Plan for Option III



Comparison Summary Costs ($) for the Four Options Analyzed

	Option I	*Option II*	*Option III*	*Option IV*
Total Capital Cost	215,100	482,000	615,850	
Total Capital Cost Per Cow	269	603		
Total Est. Annual Capital Cost	18,400	45,		
Total Est. Annual Capital Cost Per Cow	23	56		
Total Est. Annual Operating Cost	12,000	23,		
Total Est. Annual Operating Cost Per Cow	15	30		
Total Est. Annual Cost	30,400	68,		
Total Est. Annual Cost Per Cow	38	86		
Total Est. Annual Revenues	----	66,000	130,000	
Total Est. Annual Revenues Per Cow	----	82	162	
Total Est. Annual Cost or Benefit[1, 2]	-30,400	-2,800	35,200	
Total Est. Annual Cost or Benefit Per Cow	-38	-3.50	44	

- Solid-liquid separator
- Processing bldg.
- Conveyance pumps
- Plumbing and electrical
- Heat recovery

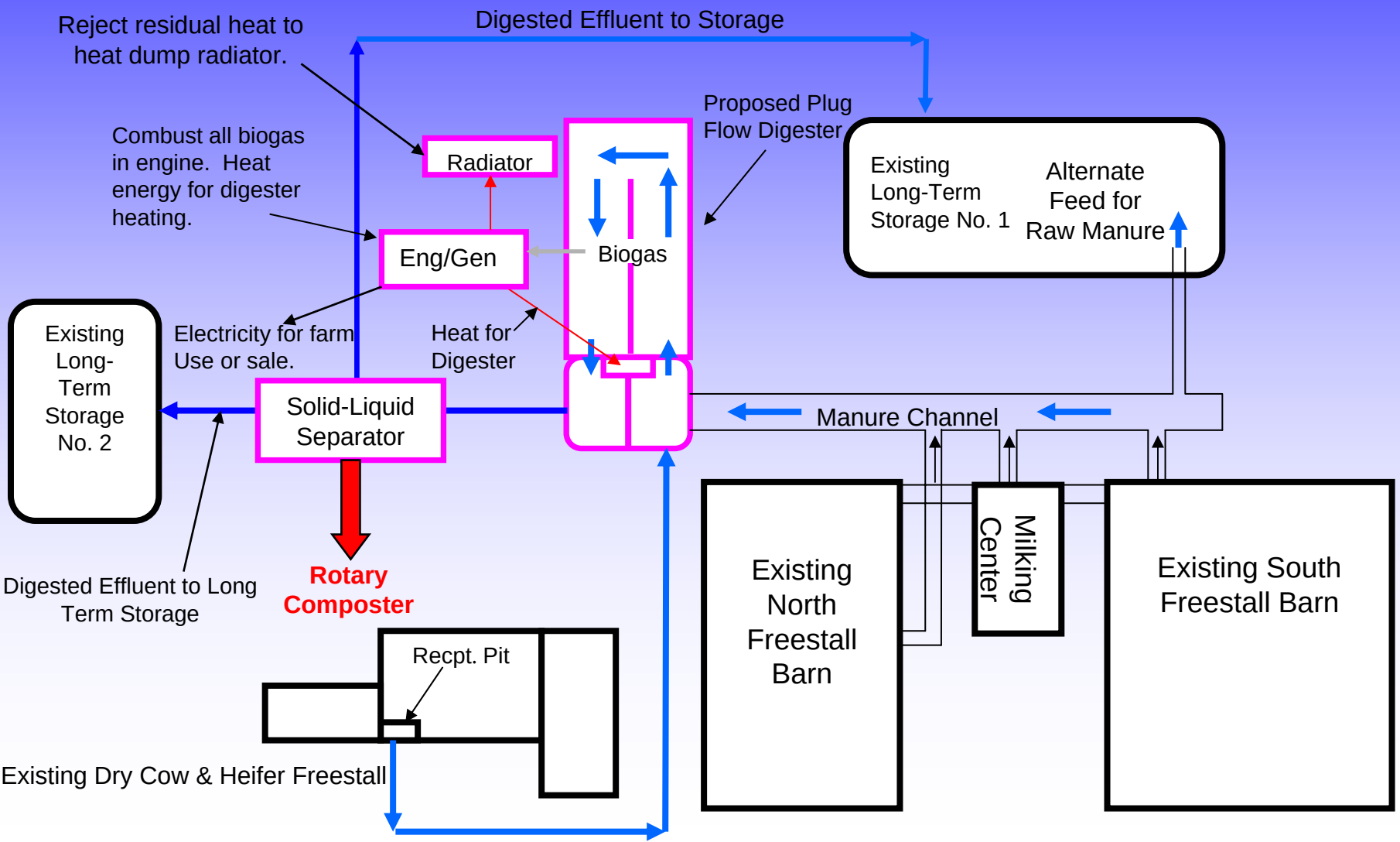
[1]Does not include treatment system electrical use (parasitic power)

[2]Negative numbers mean that the farm incurs a net loss from the digester system.

Fourth Option Analyzed

Option I.	Liquid manure odor reduction
Option II.	Option I + electrical generation
Option III.	Option II + bedding material generation & nutrient exportation
Option IV.	Option III + w/ rotary composting

Site Plan for Option III

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Comparison Summary Costs ($) for the Four Options Analyzed

	Option I	*Option II*	*Option III*	*Option IV*
Total Capital Cost	215,100	482,000	615,850	782,700
Total Capital Cost Per Cow	269	603	770	
Total Est. Annual Capital Cost	18,400	45,100		
Total Est. Annual Capital Cost Per Cow	23	56		
Total Est. Annual Operating Cost	12,000	23,700		
Total Est. Annual Operating Cost Per Cow	15	30		
Total Est. Annual Cost	30,400	68,800		
Total Est. Annual Cost Per Cow	38	86		
Total Est. Annual Revenues	----	66,000	130,000	143,600
Total Est. Annual Revenues Per Cow	----	82	162	180
Total Est. Annual Cost or Benefit[1, 2]	-30,400	-2,800	35,200	14,200
Total Est. Annual Cost or Benefit Per Cow	-38	-3.50	44	17.80

- Rotary drum composter
- Processing bldg.
- Solids conveyors
- Compost dryer
- Austere equipment

[1]Does not include treatment system electrical use (parasitic power)

[2]Negative numbers mean that the farm incurs a net loss from the digester system.

Comparisons

- On-farm electrical generation is not profitable but reduces the cost for odor control to $2,800 annually.

- Option III provides the greatest economical benefit ($35,200 annually) if post-digested reclaimed manure solids (not composted) can be used as freestall bedding material without compromising the farm's udder health and milk quality goals.

Comparisons

- If reclaimed manure solids cannot be used as bedding, then the annual cost for Option III becomes $4,400, a difference of $39,600.

- The economic benefit of aerobically composting post-digested separated solids does not exceed the cost. Option IV is only viable if use of post-digested separated solids as bedding is not permissible.

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